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TRANSPORT SYSTEM

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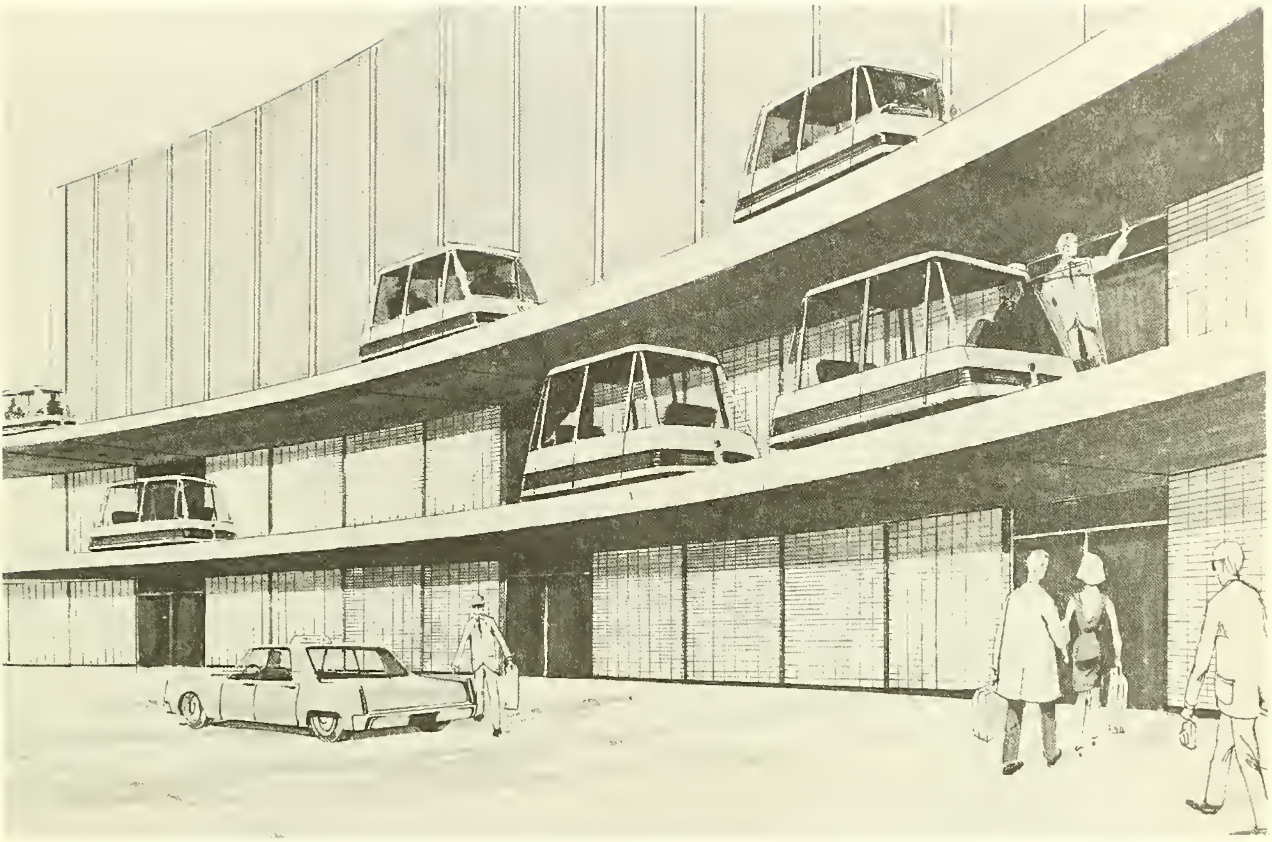

Alden Airport Vehicles

FOREWORD

This report is a technical proposal for a transport system for the Bicentennial Exposition planned for Boston in 1976. The material herein contained is considered proprietary to Alden Self-Transit Systems Corporation and is furnished to assist the Boston Expo staff in the planning of the transportation facilities of the exposition. The technical and costing data should not be disclosed, in whole or in part, to any individual or organization excepting as may be necessary for Expo planning and site selection presentation.

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I. INTRODUCTION

I. INTRODUCTION

This report summarizes information on Alden equipment and systems proposed for use as a total transportation system in the Bicentennial Exposition of 1976 planned for the City of Boston. The systems approach taken meets the total internal people transport requirements of the Exposition and provides an off-peak capability of carrying freight goods, trash, etc. Alden is interested in adapting its current systems specifically to Expo and supplying, installing, and/or operating the system during the fair.

The summary objectives of the transportation system are listed in Exhibit 1. The primary feature of the Alden approach is a selective transportation service for a family-size group direct to a specific destination without intermediate stops. The six-passenger airport-type vehicles shown in the Frontispiece serve to illustrate the type of vehicle that may be used.

The Expo transport system must meet the objectives listed and the traffic projected. Visitor estimates made have established a design day of 532,500 people with the major mode peak hour arrivals (or departures) as follows:

By MBTA (rapid transit) - 61,100 people/hr.
By automobile and bus - 32,200 people/hr.

Major station complexes are required at the Theme Center, at the Columbia MBTA interchange and at the main parking area ("Columbia Parking"). System requirements are summarized in Exhibit 2.

EXHIBIT 1

EXPO TRANSPORT-SUMMARY OBJECTIVES

- MAJOR HIGH DENSITY SERVICE WITH
  - MBTA interchange at Columbia Station
  - Bus and auto main parking area
  - Expo Center
- SELECTIVE TRANSPORT TO/FROM ALL DESTINATIONS FOR VISITORS, EMPLOYEES AND FREIGHT GOODS
- SIGHT-SEEING LOOP SERVICE AROUND KEY EXHIBITION AREAS
- POST-EXPO TRANSIT SERVICE FOR COLUMBIA POINT HOUSING CENTER, UNIVERSITY OF MASSACHUSETTS AND THOMPSON ISLAND RECREATION AREA
- ADVANCED TECHNOLOGICAL SYSTEM, IN ITSELF A MAJOR TRANSPORTATION THEME

EXHIBIT 2

SYSTEM PERFORMANCE REQUIREMENTS

1. EXPO VISITOR ESTIMATES

Design Day	532,500 people
Total Daily Arrivals and Departures	977,800 people
Peak Hour Loads	97,800 people/hour
- By bus	14,700 people/hour
- By auto	17,500 people/hour
- By rapid transit	61,100 people/hour
- By water	4,500 people/hour

2. DESIGN GOALS

Peak Loads	
Columbia Interchange	64,000 people/hour
Theme Center	133,100 people/hour
Columbia Parking	32,000 people/hour
High Density Stations	16,000 people/hour
Regular Stations	8,000 people/hour
Loops - each (Past a point)	40,000 people/hour

Transit Times	
Loop Circuit	4 minutes max
End to Center on EW and NS lines	5 minutes max

3. OVERALL ROUTING

EW Line	10 stops.....	10,720 feet
NS Line	7 stops.....	7,880 feet
Thompson Island	4 stops.....	3,320 feet
Loops		
Center	5 stops.....	4,480 feet
Northern Exhibitions	4 stops.....	3,600 feet
Eastern Exhibitions	5 stops.....	4,100 feet
TOTAL ROUTE LENGTH		34,200 feet

4. STATION COMPLEMENT

Major Complexes	3	Columbia Interchange; Theme Center; Columbia Parking
High Density Stations	13	EW & NS Line
Regular Stations	17	Loops & Thompson Island

The system proposed is a direct derivative of the "StaRRcar" prototype vehicles developed by Alden for commuter use and closed-loop airport systems, currently under development. The vehicles, as shown in the Frontispiece, are part of a system which includes a guideway structure, a control system including a central computer complex, and the necessary stations and maintenance facilities.

For urban-suburban commuter transits, the objective has been a modification of a conventional automobile which can be driven on a highway and automatically controlled on a guideway in a mass transportation system. In a closed loop system, such as in an airport, or fair, the vehicle is special purpose, operating either as a "people transporter" or a "baggage carrier".

In the development of these systems, emphasis has been placed on: (1) electrical drive with potential bi-modal capabilities (i.e., electrical battery-powered off the guideway and third rail-powered on a guideway); (2) in-vehicle switching to gain maximum flexibility and reduce costs of a guideway; (3) fully automated operation with selective origin-destination; (4) direct digital computer control for self-optimization and demand routing; (5) light-weight, modular vehicles and (6) a minimum of on-board electronics and controls to ensure a maximum of reliability.

Major improvements in "throughput" and operating economies are achieved by central computer management and the use of both dynamic and static loading in the stations; minimal guideway requirements allow considerable flexibility in by-passing stations with fully loaded vehicles or with no disembarking or embarking passengers.

The Alden systems can be effectively applied to Expo 76 and meet the objectives noted. The salient features of the system (Exhibit 3) serve to emphasis the advanced technology being employed to perform the transport function in the fair. Alden Expo Transport becomes a theme in itself and its operation has national implications in the evolving urban transportation complexes.

Alden and its major contractors and suppliers, Bedford Associates Inc. and Digital Equipment Corp. have a major interest in serving Expo Boston 76. The system proposed is a realistic application of technology meeting required performance, economic and scheduling objectives. Alden has the experience, the management interest and the expanding corporate resources to supply the system equipment and software and to operate the system as a concession, if desired. Exhibit 4 lists the key advantages of our participation in Expo 76.

The following sections consider the system concept and operation, the design approach to Expo and the background and accomplishments of our organization.

EXHIBIT 3

ALDEN SYSTEM FEATURES

- CENTRAL COMPUTER MANAGEMENT
- DIRECT COMPUTER CONTROLS
- SELECTIVE ORIGIN-DESTINATION (No intermediate stops)
- FAMILY SIZE CAPSULE
- CARGO AND PEOPLE MODULES
- OFF-PEAK OPERATION ECONOMIC AND EFFICIENT
- AUTOMATED STATIONS WITH DYNAMIC AND STATIC LOADING
- POTENTIAL BIMODAL OPERATION
- APPLICATIONS OF NATIONWIDE IMPORTANCE
  - Urban Feeder
  - Institutional Transport
  - Suburban Transits
  - Airport Baggage/People Mover
  - Industrial Materials Handling

EXHIBIT 4

ALDEN CORPORATE ADVANTAGES

- COMPANY DEDICATED TO SELECTIVE, PERSONALIZED TRANSPORT SINCE 1963
- ADVANCED SYSTEM MEETING EXPO AND POST-EXPO REQUIREMENTS RELIABLY AT LOW COSTS
- EQUIPMENT BASED UPON PROTOTYPE STARRCAR COMPUTER TRANSIT, SELECTIVE AIRPORT TRANSPORT SYSTEM IN DEVELOPMENT AND CURRENT COMPUTER TECHNOLOGY
- COMPANY AND ASSOCIATED CONTRACTORS FROM GREATER BOSTON TECHNICAL COMMUNITY
    - Responsive to Local and National Opportunity in Transportation
    - Proximity Assures Major Support in Design, Installation, Start-Up and Operation
    - Fiscal Expenditures in Greater Boston Area
- COMPANY RESPONSIVE TO FISCAL ALTERNATIVES OF EXPO
    - Will Sell and Install System to Expo or Transport Authority
    - Will Sell, Install and Operate the System
    - Will Finance, Install and Operate the System

II. GENERAL DESCRIPTION

II. GENERAL DESCRIPTION

The capsule transportation system, proposed unlike today's rapid transit train systems, provides for the movement of small groups of people or amounts of goods as efficiently and directly as possible from one point to another in the system. This is accomplished without the vehicles stopping at stations other than those designated for the particular payload.

To achieve maximum capacity in a transportation system, it is necessary to limit vehicle separation (headway) only to the stopping distance (or time) required with emergency braking. This is made possible in the Alden System by the Alden development of in-car switching (path selection), which eliminates the movement time of an in-track switch as an added time factor in headway calculations

A detailed description of the Alden Systems is beyond the scope of this report. The key control/computer subsystem determines the operating philosophy of the system, which is discussed in the following paragraphs. Exhibit 5 indicates the various subsystems and components in the Alden System. The breakdown considers the vehicle, the guideway, the control/computer and the stations as the major subsystems.

EXHIBIT 5

SUBSYSTEMS AND COMPONENTS

Subsystem	Component	Key Factors
1. Vehicle	Power and Drive	Independent electrical motors, rear wheels; commutator from guideway; position servo speed controls
	Suspension/Steering	Rubber tires; in-vehicle switch; front wheel steering; pucks engage guideway
	Body	6 passenger; 2 doors (one each side); 2 bench seats; removeable for cargo pallet
2. Guideway	Structure	Guides; curbs/walkways; installation requirements
	Electrical distribution	Power; communications; track side sensors
3. Controls	Computer	Management and self-optimization; display controls; dispatch/destination; speed/separation; launching/distribution
	Software	System image; speed profile; operational/contingency routines; display routines; performance monitoring
4. Stations	Fare collection Displays & Communication Load/Unload Platforms People/Cargo Flow	

The vehicle to be used is rubber tired to provide ride comfort similar to that of an automobile. It is steered by a "guide-follower" which is linked to the vehicle steering mechanism, and rides in a guideway at the side of the track. There are two guide-followers on each car; one to engage a guideway on each side of the vehicle. The guide followers are attached in a mechanical flip-flop configuration such that only one is engaged at a time. On a straight track only one guideway is used. At switching points, the track has guideway on both sides, and the vehicle follows the computer selected path. One or the other guide follower is engaged to implement path selection. Verification of proper operation is made prior to the actual junction point. The in-car switch thus provides path selection without the time delay normally associated with in-track switching.

The guideway is divided into speed control sections whose lengths vary in accordance with the desired vehicle speed profile on the track. It is also divided into control areas for car control and test purposes. The length of a control area is a multiple or sub-multiple of the speed control section, since the control area length is dependent upon car spacing which is related to speed control selection through its effect on car speed. Track layouts for complex systems must be designed such that the appropriate multiple of control areas (dependent on the design of the system) appears in each branch of the system with the exception of station branches. Station branches must be designed to give appropriate

starting and stopping profiles within the context of the overall control system design. There are no major limitations imposed by the control system on the complexity of the track.

The control system which provides drive signals for cars on the main track is synchronous, providing an accordian-like flow of cars around the track under central computer control. Cars are held in pre-selected positions within the flow, travelling with pre-selected speed and headway variations. Overall speed of the flow is determined by the central computer. All cars receive the same computer commands and thus act in synchronism with assured collision avoidance. Cars are launched from stations onto computer selected null points after which sensing circuitry on each car is used to modify car speed to keep the car moving along with its null point.

The computer memory contains a continuously updated record (map) of all null points and which of these are actually occupied by a car. Thus, at any moment of time, the computer can make significant calculations related, for example, to alternate paths, desired stops, destination and the launching sequence for cars about to enter the main track. All pertinent facts about each car, (e.g., destination) is carried along with the null point in the computer memory.

In the stations, passengers utilize display boards, computer controlled minimum delay messages, automatic fare collection devices and destination selection controls. Boarding and disembarking is accomplished with both static (full vehicle stop) and dynamic (vehicles moving at 1.0 to 1.5 mph) platforms. Dynamic loading increases station capacity considerably; static platforms are provided for the "less agile" and for "aborts" from dynamic load/unloads.

The computer program for the control system revolves around the map of the system stored in the computer memory. As a car goes around a track, a "software image" of that car (destination, etc.) is correspondingly circulated around the guideway image in the computer's memory. All anomalies of the track (stations, switches, sensors, power blocks, and decision points) and associated information are represented in the computer's image of the guideway.

The computer performs a variety of management and control functions for actual system operation, self-optimization and the human operators. Functions performed included vehicle position signal, vehicle launching, dispatch/destination, station displays, vehicle distribution, information reporting, central console monitoring displays, contingency and emergency planning, maintenance management, and performance monitoring. Automatic sensors and manual commands are the inputs; outputs are automated command signals, display board data, audio advisory announcements, printed reports and monitoring console data.

III. EXPO 76 SYSTEM

III. EXPO 76 SYSTEM

As has been indicated, the Alden system is configured to meet the total internal transport requirements of the fair. Although the proven subsystems and performance capabilities of an Alden system are generally in compliance with Expo needs, a specific design also has been developed. This design is based upon the qualitative and quantitative requirements set forth in Section I and upon the overall fair design as of April 1969.

Major constraints are placed by points of congestion caused by the predicted arrival mode of transportation. The estimates shown in Exhibit 2 have been translated into the high traffic demands at the rapid transit interchange at Columbia and the main parking area northeast of the Columbia station. Full advantage of the selective destination capabilities are taken, and the system is an optimum mix of high density and low density segments. The routing shown in Exhibit 6 provides full direct origin-destination selective service to the high density stations and sight-seeing loops in three exhibition areas. Station locations are as shown in Exhibit 6. The major station complexes are as follows:

> Columbia Interchange--a major interchange with the MBTA rapid transit lines (Ashmont, Old Colony and the planned Fair Loop). Traffic expected at Columbia includes those people using Savin Hill Station and 20% of those using autos and buses.

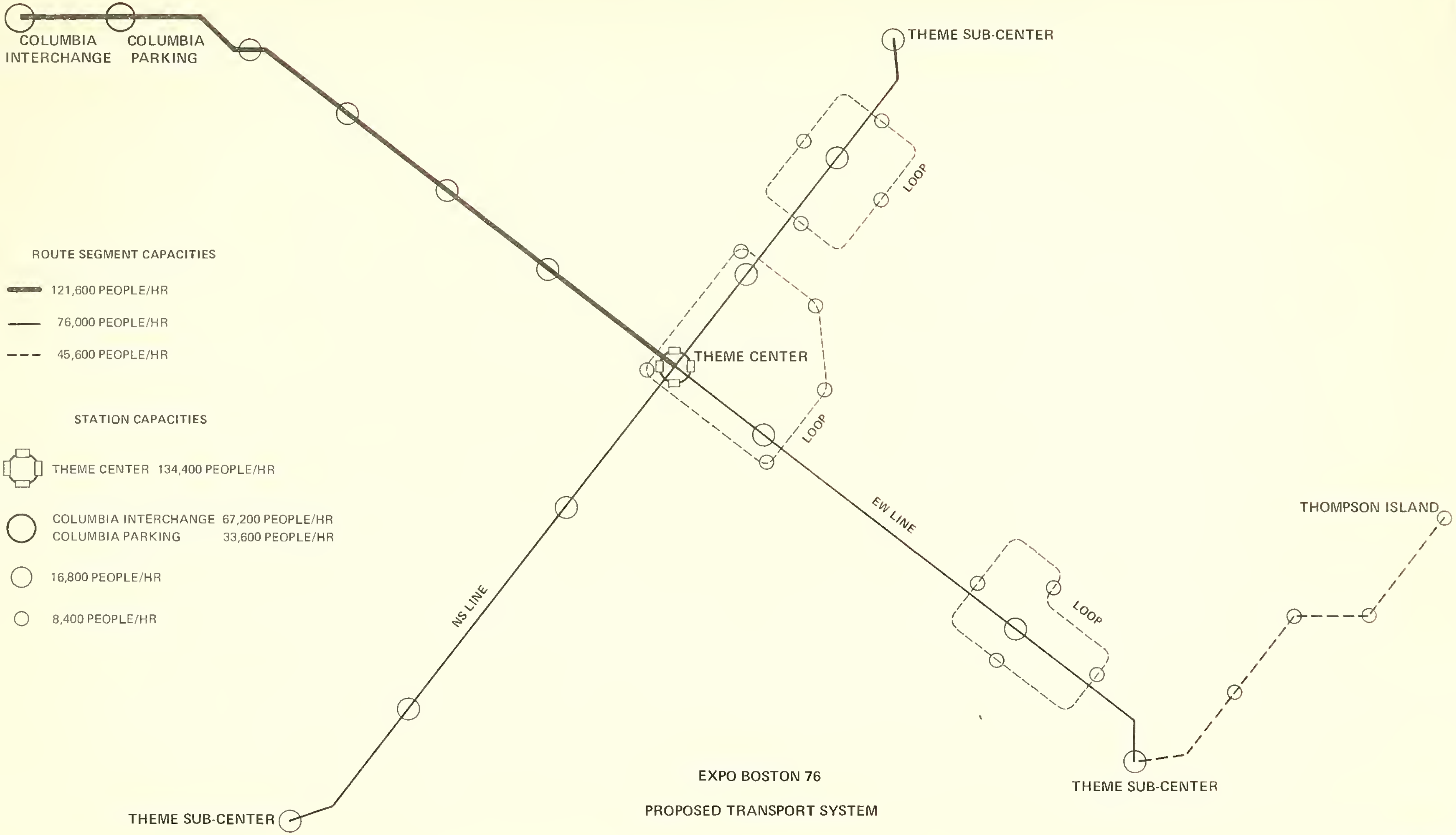
Columbia Parking--this refers to the station accommodating people using autos and buses.

Center Complex--this station complex is located in the fair center and can be expected to handle 25% of the design day as a peak load. Major provisions for bypassing within this station must be provided and station architectural complexities are severe. Preliminary thinking leans toward a 4-station configuration with the entire center complex being designed as the Federal Department of Transportation building.

A 5000 vehicle system with over 6 miles of routing is proposed which can move over 1/3 million people in an hour. Exhibit 7 summarizes system performance and Exhibit 8 presents vehicle characteristics. These vehicles are designed to have a removeable cab such that freight goods, trash, etc. can be transported at off-peak times. Special purpose vehicles operating for emergency, VIP and heavy freight purposes are also recommended. From Exhibit 7, note that the capacities on various route segments exceed the requirements shown in Exhibit 2. The limiting performance factors lie in the guideway and station "throughputs."

This transport configuration requires an integrated approach to the architectural and construction aspects of the buildings and connecting ways of the fair. This is particularly important in developing optimum vertical profiles and station facilities. The space requirements of the various route segments can be appreciated from Exhibit 9: note the space allocated for "emergency guideways", which allows for the by-pass spurs and switching as well as direct

routing for emergency vehicles. Any reduction in capacity will directly reduce these space requirements.



EXPO BOSTON 76

PROPOSED TRANSPORT SYSTEM

EXHIBIT 6

EXHIBIT 7

PERFORMANCE SUMMARY

SUBSYSTEM CHARACTERISTICS

Vehicle Performance

Speed, Operating	15 mph
Passengers	6
Braking	0.3 g
Acceleration	0.1 g

Single Guideway Capacity

Headway	25.2 ft. (2.3 sec.)
No. of cars/hr.	2,537 per guideway
Maximum people/hr.	15,200 per guideway

Single Station Platform Capacity

Dynamic Loading	1.5 mph	1,320 cars/hr.
Static Loading	--	80 cars/hrs.
		1,400 cars/hr./platform

SEGMENT CAPACITIES

	Stations People/hour	Guideway People/hour	Transit Times (Minutes)
Loops & Thompson Island Extension	8,400	45,600	3.5 max
NS Line & EW Line Center to East End	16,800	76,000	3.7 max
EW Line Center to Columbia	16,800	121,600	4.5 max

SPECIAL STATION CAPACITIES

Center Complex	134,400 people/hour
Columbia Parking	33,600 people/hour
Columbia Interchange	67,200 people/hour

VEHICLE COMPLEMENT

General Purpose Passenger	
operating	5,100 vehicles
spares	500
Special Purpose	
police, medical, VIP	100
cargo	100

OVERALL SYSTEM CAPACITY

Maximum movements in single hour (approx.)	360,000 people

EXHIBIT 8

ALDEN EXPO VEHICLE

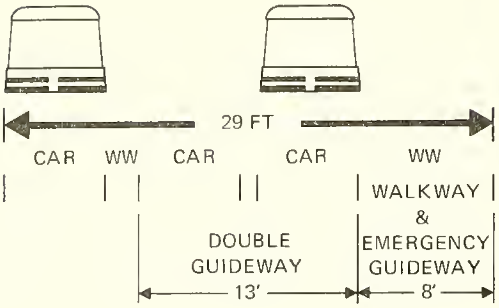
Preliminary Characteristics

External dimensions		6 feet long 6 feet wide
Capacity	- Passengers or	6 (seated)
	cargo - net payload	1250 lbs.
Weight	- maximum	3000 lbs
	- empty	1500lbs
Performance	- maximum speed	30 mph
	- operating speeds	15 mph
	- acceleration	0.1 g
	- jerk	0.075 g/sec.
	- braking, normal	0.1 g
	- braking, emergency	0.3 g to 0.5 g
	- maximum grade (no power assist)	10%

EXHIBIT 9

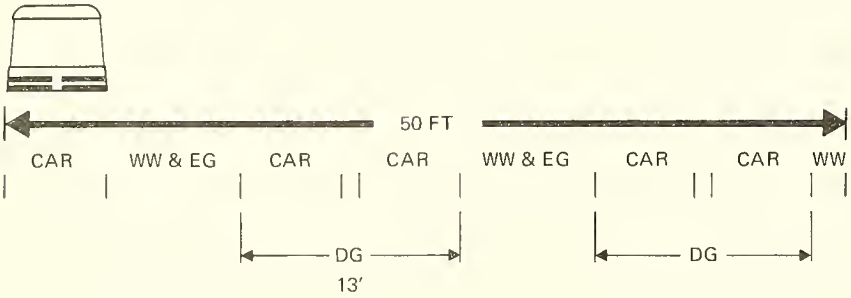
GUIDEWAY SPACE REQUIREMENTS

CROSS-SECTIONAL SILHOUETTES



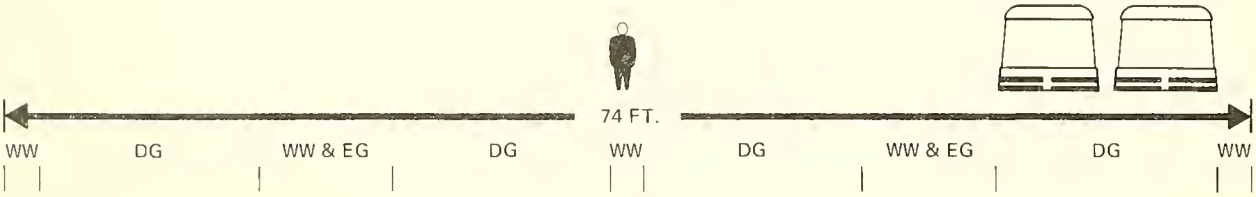
LOOPS & THOMPSON IS. EXT

45,600 PEOPLE/HR MAX CAPACITY



N-S LINE & THEME CENTER TO EASTERN THEME SUB-CENTER

76,000 PEOPLE/HR MAX CAPACITY



E-W LINE CENTER TO COLUMBIA INTERCHANGE

121,600 PEOPLE/HR, MAX CAPACITY.

IV. COST PROJECTIONS

IV. COST PROJECTIONS

Preliminary cost estimates on this system configuration are much influenced by the service desired, the routing and the architectural and construction costs. The 5,000 vehicle configuration herein proposed has well-defined capital equipment and operating costs; however, the construction costs of the guideway tunnels within buildings and the costs of station structures are interwoven with the total Expo design. The estimates provided in Exhibit 10 summarize the expected acquisition costs; note the assumptions:

1. No architectural and construction costs of guideway support structure (i.e., guideway treated as "on grade")
2. No architectural and construction costs for the major station complexes (only added costs of guideway spurs, displays, fare collection, platforms, etc.). The maintenance space requirements are likewise excluded; only equipment costs are included.

With regard to potential income, an expenditure of $1 per visitor for internal transportation appears realistic. Lower cost commutation books for employees and long-term visitors should not reduce this projected income which totals $65 million. The Expo transport operation can be profitable if realistic values are placed on the permanent structures, the post-Expo transit service provided and the vehicles, controls,

computers and other equipment which can be used in systems in other locations. Only about 1/3 of the capital expenditures of Exhibit 10 need be considered directly written off for Expo.

EXHIBIT 10

COST ESTIMATES

Subsystem & Requirements	Unit Cost	Total Acquisition Cost
VEHICLES		
Passenger (removeable cab) 5,500 required, including spares	$ 3,000	$16,500,000
Special Purpose - 200 required	6,000	1,200,000
CONTROL SYSTEM		
For 6,000 vehicles, 30 mph maximum speed, and route proposed	--	3,800,000
GUIDEWAY		
On grade including electrification, controls and voice communication, hazard protection, emergency and route switching	$90 per foot of double guideway	$ 9,500,000
Loops and Thompson Island Extension	31,000 ft.	
NS Line & EW Line Center to East End	44,800 ft.	
EW Line Center to Columbia	29,000 ft.	
Total double guideway	104,800 ft.	
STATIONS		
Including all internal structures, controls, displays, fare collection, guideways, etc.		4,900,000
Major station complexes (3 required)	$890,000 Aver.	
High density stations (13 required)	$100,000	
Regular stations (17 required)	$ 60,000	
Maintenance facilities	$200,000	
TOTAL CAPITAL EQUIPMENT COSTS		$35,900,000

V. COMPANY QUALIFICATIONS

V. COMPANY QUALIFICATIONS

Alden Self-Transit Systems Corporation was formed in 1963 to engage in the research, development and implementation of advanced personal and baggage/cargo transport systems for:

- Airports
- Industrial Complexes
- Medical Centers
- Recreational Complexes
- Suburban-Urban Complexes
- University Campuses
- World's Fairs

. . and similar areas.

Through research and development, and working with experts from the Massachusetts Institute of Technology and other consultant groups, the Company has acquired an outstanding depth of experience and know-how in transport system engineering, vehicle/roadway design, computer control, human factors engineering and other technology related to the design of automated transportation complexes. Its specific accomplishments include:

1. Design, construction and testing of a prototype bi-modal vehicle -- StaRRcar -- and demonstration of both roadway (under driver control) and guideway (under automatic steering control) operating modes.

2. Invention and patenting of a unique in-vehicle switch (incorporated in StaRRcar) which permits closer headways with safety on the guideway and safe merging and de-merging of vehicles with very close headways.

3. Development of electronic controls and computer hardware and software for full-automatic operation of a selective transport system, including dispatch, destination, route selection and speed control in response to passenger demand and traffic conditions.

4. Demonstration of this system, using a Digital Equipment Corporation Model PDP-8/L Computer to manage and control a 1/24-scale model transportation complex having 10 model cars with multiple paths and destinations.

Alden research and development are carried out by Bedford Associates, Inc., Bedford, Mass., an engineering firm specializing in computer control and interface devices. The 1/24-scale model guideway network is located at the Bedford facility.

Alden's current developmental programs include:

1. Design and construction of third-generation vehicles and guideway for demonstrating and testing of a full-scale prototype transport system under full computer control.
2. Analysis of vehicle requirements and design of vehicle configurations to meet possible market needs.
3. Analysis and planning of selective automatic transport systems for specific application in airports and other high-density traffic areas.

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